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this State. Our observations on this point are limited to the brief period of two complete years, during which time the average relative humidity was 66.4, complete saturation being represented by 100. By this is meant that upon the average the air contained two-thirds of the amount of moisture it was capable of containing. This percentage of moisture forms a very desirable mean between the very moist and the very dry, being alike favorable to the healthful condition of man, the domestic animals and the growing crops. The relative humidity at Philadelphia is 72, the air containing nearly three-fourths the amount of moisture required for saturation.

I have thus briefly touched upon the most important features of the climate of Kansas, as illustrated by my own observations, trusting that these results may lead to a more accurate knowledge of the subjects involved than is generally possessed by the citizens of Kansas and other States.

Respectfully yours,

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## GEOLOGY OF THE ARKANSAS.

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BY B. F. MUDGE.

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This paper is based on observations made in the Arkansas valley at various visits during the past five years, and particularly on a trip recently made as far west as Fort Aubrey, near the Kansas and Colorado line. We confine our remarks to that part between Hutchinson and Fort Aubrey, or that portion covered by the red sandstone of the Cretaceous period.

Observations made the past year confirm the statement in one of my papers read before a former meeting of this Association, viz.: that there is in Kansas no geological representation of the formations found in other countries, between the upper Carboniferous measures or Permian, and the Cretaceous. Careful search has been made for fossils of Jurassic and Triassic periods along the western borders of the Permian, and none have been found, while dicotyledonous leaves and other Cretaceous fossils have lately been procured nearer the line of the Permian than during our first collections.

The Arkansas valley, by its fossils, shows the same peculiarity.

The fossils nearest the Permian are *Ostrea congesta* and dicotyledonous leaves, two species of the latter, found by us a year ago near Fort Larned, being new to science.

Probably it is well known to this association that the outcrop of nearly all of the coal strata of our State have a strike northeast and southwest, and that they can be followed across the State in those directions. This also applies to all strata of the Cretaceous in the northern half of the State. This rule holds true of the red sandstone of the Cretaceous formation, from the Nebraska line in Washington county to Pawnee Rock in the Arkansas valley, but when reaching this valley the rule ceases.

The average breadth of this sandstone in the northern half of the State is about forty miles (northwest and southeast), or about sixty in a diagonal line running due east and west. But when it reaches the bluffs of the Arkansas valley the strike is westerly, and instead of a westerly extension of sixty miles, it covers the whole country from thirty miles east of Pawnee Rock to the western line of the State, a distance of about two hundred miles. This shows that the ocean which favored the deposit of the upper portion of the Cretaceous, so rich in vertebrate fossils, either did not extend in that direction, or from some local cause was not favorable to such animal life. Had the ocean extended in that direction, but was turbid or deep, too cold or too salt, then no chalk deposit would have taken place. Some one at least of these conditions must have existed for a long period.

The sandstone is much varied in condition and appearance. Near Fort Larned and for seventy miles eastward much of it is of uniform texture and hardness, so that it furnishes a good building material. The buildings of old Forts Zarah, Harker and Larned are constructed of it. Care, however, must be used in selection, as much of it is too soft. Farther west it is more loose in texture, so that for thirty miles on either side of Fort Dodge it is too friable and crumbling to be used in forming culverts and buildings, and the railroad now in construction through this valley has frequently been obliged to transport its stone ten or twelve miles. From Fort Dodge to the western line of the State, a distance of 115 miles, the stone is mixed with some lime in a chalky state, which makes the sandstone still more friable.

The strata are not clearly defined in thickness or extent. In some places, particularly west of Dodge, the deposit varies in a great degree. In some spots it is fine, and in others it is mingled with pebbles of flint, quartz, and other silicious stones of the size of the fist. Instances of oblique stratification often occur, usually of coarse

material, showing that the shores of the old ocean had strong local currents. The whole deposit is so nearly horizontal for two hundred miles, that the inclination of the strata, if any exists, could not be detected. The few finely preserved leaves of land plants which have been found, show the existence of islands in the Cretaceous.

Invertebrate fossils are seen at but few points east of Fort Dodge; but in that vicinity and west of it, they are more frequently found. They are restricted to a few species, mostly represented by *ostrea* and *inoceramus*. Fossils of a higher type are extremely rare. During two weeks' search, the only specimen obtained was a single palatal tooth of a fish, *Ptychodus*.

The character of the materials, uniformity, and level state of the deposition, together with the scarcity of organic remains, renders the geology of this part of Kansas the most monotonous we have ever examined.

Such a formation in any part of the world, has never yet yielded any mineral wealth. I make this statement lest any of our new settlers should waste time and capital in a fruitless search for valuable ores. The red appearance of much of the sandstone is caused by iron. In some places this at first sight would raise the presumption that that metal could be procured in paying quantities. This, however, is not the case. While in the best cases the percentage of iron is low, the quality is quite objectionable. The silicates are so mixed with the metal that only a poor article of iron could be sent to market. I make this statement in the face of an assertion made on our visit that a good iron ore of seventy per cent. had been found near Pawnee Rock. But it is equally the duty of a geologist to tell what geological formations do not produce valuable ores, as to point out good localities.

The soil of a country underlaid by such a deposit would naturally be sandy. To a certain extent this is true of the Arkansas valley, but not so much so as to interfere with a good share of fertility. The higher lime strata of the Cretaceous undoubtedly at a former period covered all this part of the State. The abundant fertile elements of those old limestones are intermingled with the present surface soil, and give to it in most places a fine, rich soil. Consequently this valley, to a very large extent, contains excellent farming lands. On the high prairie the black loam is like that in other parts of Kansas, very rich, and from two to three feet in depth. In the valley the loam is from one to ten feet deep, and more intermingled with sand. From Fort Larned easterly, the valley is more or less cultivated, and the crops compare favorably with

other portions of the State. From that place westwardly, the appearance of the soil continues promising. The portion not fertile is confined almost entirely to the south bank of the river, and consists of a belt of sandy hills covered with coarse grass and bushes, and sprinkled with a few trees. These hills will undoubtedly be turned to profit in raising forest trees, to which they appear well adapted.

The only question to be raised in relation to the settlement of the valley is that of rain. This, however, applies only to the country west of Fort Larned. Thus far there have been no forts or settlement for a length of time sufficient to settle this important question. We found some ponds on the high prairies west of Fort Dodge, but the present season has been one of more than ordinary rainfall.

Like all sandstone countries, the water in the wells is good. In any portion of the bottom (in some places fifteen miles wide) it is found at from six to twenty-five feet from the surface.

The contractors of the Atchison, Topeka & Santa Fe railroad sunk "drive" wells at intervals of two or three miles, and uniformly found good water. In only one instance did we learn of a spring or well of alkali water, and that was a few miles from Fort Aubrey.

The river has a very gentle and uniform descent, according to the railroad surveys, of seven feet to the mile. The entire range between high and low water mark is not over five feet. This, on a river averaging one-third of a mile in width, is most remarkable. In this part of the valley it never overflows its banks. The peculiarities of the river, and uniformity of level in the bottom, renders the valley a favorable situation to try the benefits of irrigation. As this method of farming has not been applied in Kansas, we hope some company will be formed to make the experiment.